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# UTILITY PATENT APPLICATION TRANSMITTAL

Attorney Docket No.	003364.P035	Total Pages (all documents)	PTO
First Named Inventor or Application Identifier Woo			
LITHIUM SECONDARY BATTERS			
Express Mail Label No.	EM014064465US		

(Only for new nonprovisional applications under 37 CFR 1.53(b))

U.S. PTO  
09/494211  
01/25/00

## APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

ADDRESS TO:

Assistant Commissioner for Patents  
Box Patent Application  
Washington, DC 20231

1. ☒ \*Fee Transmittal Form (e.g. PTO/SB/17)  
(Submit an original, and a duplicate for fee processing)
2. ☒ Specification *Total Pages*   
(preferred arrangement set forth below)
  - Descriptive Title of the Invention
  - Cross References to Related Applications
  - Statement Regarding Fed sponsored R&D
  - Reference to Microfiche Appendix
  - Background of the Invention
  - Brief Summary of the Invention
  - Brief Description of the Drawings (if filed)
  - Detailed Description
  - Claims
  - Abstract of the Disclosure
3. ☐ Drawing(s) (35 USC 113) *Total Sheets*   
☒ Oath of Declaration *Total Pages* 
  - a. ☒ Newly executed (original copy)
  - b. ☐ Copy from prior application (37 CFR 1.63(d))  
(for continuation/divisional with Box 17 completed)
  - i. ☐ DELETION OF INVENTOR(S)  
Signed statement attached deleting inventor(s) named in prior application, see 37 CFR 1.63(d)(2) and 1.33 (b).
4. ☐ Microfiche Computer Program (Appendix)
5. ☐ Nucleotide &/or Amino Acid Sequence Submission  
(if applicable, all necessary)
  - a. ☐ Computer Readable Copy
  - b. ☐ Paper Copy (identical to computer copy)
  - c. ☐ Statement verifying identity of above copies

## ACCOMPANYING APPLICATION PARTS

7. ☒ Assignment Papers (cover sheet & document(s))
8. ☐ 37 CFR 3.73(b) Statement ☐ Power of Attorney  
(when there is an assignee)
9. ☐ English Translation Document (if applicable)
10. ☐ Information Disclosure ☐ Copies of IDS  
Statement (IDS)/PTO-1449 Citations
11. ☐ Preliminary Amendment
12. ☒ Return Receipt Postcard (MPEP 503)
13. ☐ \*Small Entity ☐ Statement filed in prior app  
Statement(s) Status still proper and desired
14. ☐ Certified Copy of Priority Document(s)  
(if foreign priority is claimed)
15. ☒ Other: REQUEST FOR PRIORITY

\* Note for Items 1 & 13: In order to be entitled to pay small entity fees, a small entity statement is required (37 CFR §1.27), except if one filed in a prior application is relied upon (37 CFR §1.28)

16. If a CONTINUING APPLICATION, check appropriate box and supply the requisite information below & in a preliminary amendment:

☐ Continuation ☐ Divisional ☐ Continuation-in-part (CIP) of prior application no: \_\_\_\_\_

Prior application information: Examiner: \_\_\_\_\_ Group/Art Unit: \_\_\_\_\_

For Continuation or Divisional Apps only: The entire disclosure of the prior application, from which an oath or declaration is supplied under Box 4b, is considered a part of the disclosure of the accompanying continuation or divisional application and is hereby incorporated by reference. The incorporation can only be relied upon when a portion has been inadvertently omitted from the submitted application parts.

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Signature		Date January 24, 2000

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IN THE UNITED STATES PATENT AND TRADEMARK

In re application of: )  
IL-KI WOO )  
For: **LITHIUM SECONDARY BALLAST** )  
\_\_\_\_\_ )

PRELIMINARY AMENDMENT

Hon. Commissioner of Patents and Trademarks  
Washington, D.C. 20231

Dear Sir:

Please add the following claim:

--3. A method for making a lithium secondary battery comprising  
the steps of:

forming a positive electrode by coding the metal oxides on a  
positive current collector;

forming a negative electrode by coding carbonaceous materials  
or  $\text{SnO}_2$  on a negative current collector; the negative current  
collector being made of a Cu-based alloy foil with a thickness of  
20  $\mu\text{m}$  or less and the Cu-based alloy foil including at least one  
material selected from the group consisting of nickel, titanium,  
magnesium, tin, zinc, boron, chromium, manganese, silicone,  
cobalt, iron, vanadium, aluminum, zirconium, niobium, phosphorous,  
bismuth, lead, silver, and misch metal;

a separator interposed between the positive and negative  
electrodes; and

an electrolyte into which the positive and negative  
electrodes and the separator are immersed

17 interposing a separator between the positive and negative  
18 electrodes; and  
19 immersing the positive and negative electrodes and the  
20 separator into an electrolyte.--

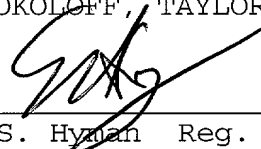
**REMARKS**

Entry of the foregoing amendment is requested.

Respectfully submitted,

BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN

Dated: 1/24/2000

By:   
Eric S. Hyman Reg. No. 30,139

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Our Ref.: 003364.P035  
**Express Mail No. EM014064465US**

UTILITY APPLICATION FOR UNITED STATES PATENT

FOR

**LITHIUM SECONDARY BATTERY**

Inventor(s): Il-Ki Woo et al.

# **LITHIUM SECONDARY BATTERY**

## **CROSS REFERENCE TO RELATED APPLICATION**

This application is based on applications Nos. 99-2257 and 99-51148 respectively filed in the Korean Industrial Property Office on January 25, 1999 and November 17, 1999, the contents of which are incorporated hereinto by reference.

## **BACKGROUND OF THE INVENTION**

### **(a) Field of the Invention**

The present invention relates to a lithium secondary battery and, more particularly, to a lithium secondary battery which exhibits particular mechanical properties using a thin negative current collector.

### **(b) Description of the Related Art**

Conventionally, a copper foil with at least 99.8% purity has been used as a negative current collector for a lithium secondary battery. During charge and discharge, a negative electrode is expanded (an expansion of about 10%) and the expansion results in a tensile stress in a current collector made of the copper foil. However, as the durable tensile strength of copper foil is low, such a foil is easily torn.

The weak tensile strength of copper foil makes it difficult to reduce the thickness of the copper foil, which prohibits an increase in an amount of a negative active material in a battery. Accordingly, it is impossible to produce a battery having high capacity using copper foil.

## **SUMMARY OF THE INVENTION**

It is an object of the present invention to provide a lithium secondary battery exhibiting good tensile strength.

It is another object to provide a lithium secondary battery using a thin negative current collector.

These and other objects may be achieved by a lithium secondary battery including a positive electrode formed by coating lithium metal oxides on a positive current collector, and a negative electrode formed by coating carbonaceous materials or  $\text{SnO}_2$  on a negative current collector. The negative current collector is made of a Cu-based alloy foil with a thickness of 20  $\mu\text{m}$  or less and the Cu-based alloy foil includes at least one material selected from the group consisting of nickel, titanium, magnesium, tin, zinc, boron, chromium, manganese, silicone, cobalt, iron, vanadium, aluminum, zirconium, niobium, phosphorous, bismuth, lead, silver, and misch metal. The lithium secondary battery further includes a separator interposed between the positive and negative electrodes and an electrolyte into which the positive and negative electrodes and the separator are immersed.

## **DETAILED DESCRIPTION OF THE INVENTION**

The present invention provides a lithium secondary battery exhibiting high capacity. The lithium secondary battery is manufactured by using a Cu-based alloy foil having both a good tensile strength and a thin thickness.

The Cu-based alloy foil includes at least one material selected from nickel, titanium, magnesium, tin, zinc, boron, chromium, manganese, silicone,

5 cobalt, iron, vanadium, aluminum, zirconium, niobium, phosphorous bismuth,  
lead, silver and misch metal. The amount of nickel is 0.8 to 4 wt% of the  
copper, that of titanium is 0.2 to 4 wt% of the copper, that of magnesium is 0.05  
to 0.6 wt% of the copper, and that of tin is 0.1 to 2.0 wt% of the copper. The  
amount of zinc is 0.0005 to 0.5 wt% of the copper, that of boron is 0.0005 to 5.0  
wt% of the copper, that of chromium is 0.0005 to 0.5 wt% of the copper, and  
that of manganese is 0.1 to 1.0 wt% of the copper. The amount of silicone is  
0.1 to 0.5 wt% of the copper, that of iron or cobalt is 0.01 to 2.0 wt% of the  
copper, that of vanadium is 0.0005 to 0.5 wt% of the copper, and that of  
10 aluminum is 0.005 to 0.5 wt% of the copper. The amount of zirconium is  
0.0005 to 0.5 wt% of the copper, that of niobium is 0.0005 to 0.5 wt% of the  
copper, that of phosphorous is 0.02 to 0.16 wt% of the copper, that of bismuth  
is 0.0005 to 0.5 wt% of the copper, that of lead is 0.0005 to 0.5 wt% of the  
copper, and that of silver is 0.0005 to 0.5 wt% of the copper. If the materials  
15 are out of this range, it is difficult to obtain a foil having the desirable tensile  
strength.

The Cu-based alloy foil is generally produced by an electro-plating  
process or a cold-rolling process.

20 In the battery of the present invention, the positive electrode may be  
produced by dissolving lithium metal oxides such as  $\text{LiCoO}_2$ ,  $\text{LiNiO}_2$ ,  $\text{LiMnO}_2$ ,  
 $\text{LiMn}_2\text{O}_4$  and a polyvinylidene fluoride binder in N-methyl pyrrolidone to make a  
slurry, coating the slurry on a positive collector made of aluminum foil, and  
drying the coated collector.

The negative electrode may be produced by dissolving an active

material into or from which lithium ions are intercalated or deintercalated (i. e. carbonaceous materials such as crystalline carbon or amorphous carbon, or SnO<sub>2</sub>) and a polyvinylidene binder in N-methyl pyrrolidone to make a slurry. The slurry is coated on a negative collector of the present invention and then dried. The negative collector preferably has a thickness of 20  $\mu\text{m}$  or less and the Cu-based alloy foil with about 15  $\mu\text{m}$  of thickness can be used for the collector without the deterioration of mechanical properties, such as its tensile strength.

The separator may be a porous film made of polyethylene or polypropylene.

The electrolyte may be a 1M solution prepared by dissolving LiPF<sub>6</sub>, LiAsF<sub>6</sub>, LiCF<sub>3</sub>SO<sub>3</sub>, LiN(CF<sub>3</sub>SO<sub>2</sub>)<sub>3</sub>, LiBF<sub>6</sub>, or LiClO<sub>4</sub> in an organic solvent. The organic solvent may be of cyclic carbonates such as propylene carbonate or ethylene carbonate, linear carbonates such as dimethyl carbonate, or diethyl carbonate, or a mixture thereof.

The following examples further illustrate the present invention.

#### Examples 1 to 4 and Comparative Examples 1 to 2

Foil types for negative current collectors were manufactured according to the compositions shown in Table 1. The electrolytic copper foil was used in Comparative example 1 and the rolled copper foil was used in Comparative example 2. The tensile strengths thereof were measured and the results are present in Table 1. In Table 1, "Com." refers to "comparative example".



Table 1

	Composition	Tensile strength [N/mm <sup>2</sup> ]
Example 1	Ni: 1.8 wt%, Ti: 1.1 wt%, Cu: balance	560
Example 2	Ni: 2.0 wt%, Ti: 0.9 wt%, Mg: 0.13 wt%, Cu: balance	620
Example 3	Ni: 2.0 wt%, Ti: 1.1 wt%, Mg: 0.29wt%, Mn: 0.52 wt%, Cu: balance	620
Example 4	Ni: 1.5 wt%, Ti: 0.9 wt%, Mg: 0.26 wt%, Zn: 0.20 wt%, Cu: balance	630
Comp. 1	Cu: at least 99.9 wt%	420
Comp. 2	Cu: at least 99.9 wt%	340

As shown in Table 1, the collectors of Examples 1 to 4 have superior tensile strength to those of Comparative Examples 1 to 2. The collector of Example 4 having 1.5 wt% of nickel, 0.9 wt% of titanium, 0.26 wt% of magnesium, and 0.20 wt% of zinc has the highest tensile strength.

As described, the present invention provides a negative current collector exhibiting improved mechanical strength and thermal conductivity by adding materials such as nickel or titanium to copper. The negative current collector of the present invention exhibits good tensile strength such that a wide collector can be produced to improve workability, and the thickness of current collector can be reduced to increase the capacity of the battery.

While the present invention has been described in detail with reference to the preferred embodiments, those skilled in the art will appreciate that various modifications and substitutions can be made thereto without departing from the spirit and scope of the present invention as set forth in the appended claims.

copper, the amount of zirconium is 0.0005 to 0.5 wt% of copper, the amount of niobium is 0.0005 to 0.5 wt% of copper, the amount of phosphorous is 0.02 to 0.16 wt% of copper, the amount of bismuth is 0.0005 to 0.5 wt% of copper, the amount of lead is 0.0005 to 0.5 wt% of copper, and the amount of silver is 0.0005 to 0.5 wt% of copper.

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**WHAT IS CLAIMED IS:**

1. A lithium secondary battery comprising:

a positive electrode formed by coating lithium metal oxides on a positive current collector;

5 a negative electrode formed by coating carbonaceous materials or  $\text{SnO}_2$  on a negative current collector; the negative current collector being made of a Cu-based alloy foil with a thickness of 20  $\mu\text{m}$  or less and the Cu-based alloy foil including at least one material selected from the group consisting of nickel, titanium, magnesium, tin, zinc, boron, chromium, manganese, silicone, cobalt, iron, vanadium, aluminum, zirconium, niobium, phosphorous, bismuth, lead, silver, and misch metal;

a separator interposed between the positive and negative electrodes;

and

an electrolyte into which the positive and negative electrodes and the separator are immersed.

2. The lithium secondary battery of claim 1 wherein the amount of nickel is 0.8 to 4 wt% of copper, the amount of titanium is 0.2 to 4 wt% of copper, the amount of magnesium is 0.05 to 0.6 wt% of copper, the amount of tin is 0.1 to 2.0 wt% of copper, the amount of zinc is 0.0005 to 0.5 wt% of copper, the amount of boron is 0.0005 to 5.0 wt% of copper, the amount of chromium is 0.0005 to 0.5 wt% of copper, the amount of manganese is 0.1 to 1.0 wt% of copper, the amount of silicone is 0.1 to 0.5 wt% of copper, the amount of iron or cobalt is 0.01 to 2.0 wt% of copper, the amount of vanadium is 0.0005 to 0.5 wt% of copper, the amount of aluminum is 0.005 to 0.5 wt% of

### **ABSTRACT OF THE DISCLOSURE**

A lithium secondary battery exhibiting good mechanical properties and using a thin negative current collector is provided. The lithium secondary battery includes a positive electrode formed by coating lithium metal oxides on a positive current collector and a negative electrode formed by coating carbonaceous materials or  $\text{SnO}_2$  on a negative current collector. The negative current collector is made of a Cu-based alloy foil with a thickness of 20  $\mu\text{m}$  or less and the Cu-based alloy foil includes at least one material selected from the group consisting of nickel, titanium, magnesium, tin, zinc, boron, chromium, manganese, silicone, cobalt, iron, vanadium, aluminum, zirconium, niobium, phosphorous, bismuth, lead, silver and misch metal. The lithium secondary battery further includes a separator interposed between the positive and negative electrodes and an electrolyte into which the positive and negative electrodes and the separator are immersed.

Our Ref.: 003364.P035

DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below, next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled "LITHIUM SECONDARY BATTERY"

the specification of which

  X   is attached hereto.  
       was filed on \_\_\_\_\_ as  
Application Serial No. \_\_\_\_\_  
and was amended on \_\_\_\_\_  
(if applicable)

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above. I do not know and do not believe that the same was ever known or used in the United States of America before my invention thereof, or patented or described in any printed publication in any country before my invention thereof or more than one year prior to this application, that the same was not in public use or on sale in the United States of America more than one year prior to this application, and that the invention has not been patented or made the subject of an inventor's certificate issued before the date of this application in any country foreign to the United States of America on an application filed by me or my legal representatives or assigns more than twelve months prior to this application.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119, of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

<u>Prior Foreign Application(s)</u>			<u>Priority Claimed</u>	
<u>99-2257</u> (Number)	<u>Korea</u> (Country)	<u>25/01/1999</u> (Day/Month/Year Filed)	<u>  X  </u> Yes	<u>      </u> No
<u>99-51148</u> (Number)	<u>Korea</u> (Country)	<u>17/11/1999</u> (Day/Month/Year Filed)	<u>  X  </u> Yes	<u>      </u> No

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, Section 112, I acknowledge the duty to disclose

material information as defined in Title 37, Code of Federal Regulations, Section 1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

(Application Serial No.)	(Filing Date)	(Status -- patented, pending, abandoned)
(Application Serial No.)	(Filing Date)	(Status -- patented, pending, abandoned)
(Application Serial No.)	(Filing Date)	(Status -- patented, pending, abandoned)

I hereby appoint BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP, a firm including: Farzad E. Amini, Reg. No. 42,261; Aloysius T. C. AuYeung, Reg. No. 35,432; William Thomas Babbitt, Reg. No. 39,591; Carol F. Barry, 41,600; Jordan Michael Becker, Reg. No. 39,602; Bradley J. Berezna, Reg. No. 33,474; Michael A. Bernadieu, Reg. No. 35,934; Roger W. Blakely, Jr., Reg. No. 25,831; Gregory D. Caldwell, Reg. No. 39,926; Kent M. Chen, Reg. No. 39,630; Lawrence M. Cho, Reg. No. 39,942; Yong S. Choi, Reg. No. 43,324; Thomas M. Coester, Reg. No. 39,637; Roland B. Cortes, Reg. No. 39,152; Barbara Bokanov Courtney, Reg. No. P42,442; William Donald Davis, Reg. No. 38,428; Michael Anthony DeSanctis, Reg. No. 39,957; Daniel M. De Vos, Reg. No. 37,813; Tarek N. Fahmi, Reg. No. P41,402; James Y. Go, Reg. No. 40,621; Richard Leon Gregory, Jr., P42,607; Dinu Gruia, Reg. No. 42,996; David R. Halvorson, Reg. No. 33,395; Thomas A. Hassing, Reg. No. 36,159; James A. Henry, Reg. No. 41,064; Phuong-Quan Hoang, 41,839; Willmore F. Holbrow III, Reg. No. P41,845; George W. Hoover II, Reg. No. 32,992; Eric S. Hyman, Reg. No. 30,139; Dag H. Johansen, Reg. No. 36,172; William W. Kidd, Reg. No. 31,772; Tim L. Kitchen, Reg. No. P41,900; Michael J. Mallie, Reg. No. 36,591; Paul A. Mendonsa P42,879; Darren J. Milliken, P42,004; Tinh V. Nguyen, Reg. No. 42,034; Kimberley G. Nobles, Reg. No. 38,255; Michael A. Proksch P43,021; Babak Redjaian, Reg. No. 42,096; James H. Salter, Reg. No. 35,668; William W. Schaal, Reg. No. 39,018; James C. Scheller, Reg. No. 31,195; Anand Sethuraman, Reg. No. 43,351; Charles E. Shemwell, Reg. No. 40,171; Maria McCormack Sobrino, Reg. No. 31,639; Stanley W. Sokoloff, Reg. No. 25,128; Allan T. Sponseller, Reg. No. 38,318; Geoffrey T. Staniford, P43,151; Judith A. Szepesi, Reg. No. 39,393; Vincent P. Tassinari, Reg. No. 42,179; Edwin H. Taylor, Reg. No. 25,129; George G. C. Tseng, Reg. No. 41,355; Lester J. Vincent, Reg. No. 31,460; John Patrick Ward, Reg. No. 40,216; Stephen Warhola, P43,237; Charles T. J. Weigell, Reg. No. 43,398; Ben J. Yorks, Reg. No. 33,609; and Norman Zafman, Reg. No. 26,250; my attorneys; and Amy M. Armstrong, Reg. No. P42,265; Robert Andrew Diehl, Reg. No. P40,992; and Edwin A. Sloane, Reg. No. 34,728; my patent agents, with offices located at 12400 Wilshire Boulevard, 7th Floor, Los Angeles, California 90025, telephone (310) 207-3800, with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected herewith.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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Inventor's Signature Il-Ki Woo Date January 5, 2000

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